

RESULTS OF PRESBYOPIA CORRECTION WITH MULTIFOCAL PROFILE APPLICATION ON THE CORNEA BY PHOTOREFRACTIVE KERATECTOMY IN HYPEROPIC PATIENTS

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✧ **Aim.** To compare the efficacy, safety, and predictability of simultaneous hyperopia and presbyopia correction using photorefractive keratectomy (PRK) with the application of a bi-aspheric multifocal profile on the cornea using PresbyMax software and hyperopia correction using LASIK. **Methods.** Overall, 50 patients were divided into two groups: 25 patients (50 eyes) in group 1 underwent PRK with bi-aspheric multifocal profile application on the cornea using PresbyMax software for simultaneous hyperopia and presbyopia correction. Group 2 included 25 patients (50 eyes) who underwent LASIK with aspheric profile application on the cornea for hyperopia correction. **Results.** One year after surgery in group 1, binocular distance uncorrected visual acuity (DUCVA) was 0.96 ± 0.16 , near uncorrected visual acuity (NUCVA) was 0.77 ± 0.17 , and intermediate uncorrected visual acuity (IUCVA) was 0.64 ± 0.15 . Visual acuity loss of up to 0.2 was found in two eyes (4%). Target refraction in the dominant eye (emmetropia) was obtained in 72% of patients; in 28% of cases, a shift up to -0.75 D was observed. Target refraction in the non-dominant eye was found in 68% of patients, 12% of patients had a shift from the target refraction of -0.50 D, and 20% of patients of -0.75 D. Spherical aberration in the 6-mm zone was -0.22 ± 0.17 μm . One year after surgery in group 2, binocular DUCVA was 1.0 ± 0.10 , NUCVA was -0.37 ± 0.16 , and IUCVA was -0.43 ± 0.12 . No monocular best corrected distance visual acuity loss was found. A myopic shift from the planned target (emmetropia) of -0.50 D was established in 4% of patients. Spherical aberration in the 6-mm zone was -0.10 ± 0.08 μm . **Conclusion.** PRK with bi-aspheric multifocal profile application, unlike LASIK, not only achieves hyperopia correction but also improves near visual acuity in patients of presbyopic age.

✧ **Keywords:** presbyopia; hyperopia; LASIK; PRK; bi-aspheric multifocal profile; PresbyMax.

РЕЗУЛЬТАТЫ КОРРЕКЦИИ ПРЕСБИОПИИ ПУТЕМ НАНЕСЕНИЯ МУЛЬТИФОКАЛЬНОГО ПРОФИЛЯ НА РОГОВИЦУ МЕТОДОМ ФОТОРЕФРАКЦИОННОЙ КЕРАТЭКТОМИИ У ПАЦИЕНТОВ С ГИПЕРМЕТРОПИЕЙ

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✧ **Цель.** сравнить эффективность, безопасность и прогнозируемость одномоментной коррекции гиперметропии и пресбиопии методом фоторефракционной кератэктомии (ФРК) при нанесении мультифокального биасферического профиля на роговицу с помощью программного обеспечения «Пресбимакс» и коррекции гиперметропии методом ЛАСИК. **Методы.** В группе 1 (25 пациентов (50 глаз)) операции проводились методом ФРК с нанесением мультифокального биасферического профиля на роговицу для одномоментной коррекции гиперметропии и пресбиопии. Группу 2 (25 пациентов (50 глаз)) составили пациенты, прооперированные методом ЛАСИК с нанесением асферического профиля для коррекции

гиперметропии. **Результаты.** В группе 1 через год после операции бинокулярная некорригированная острота зрения (НКОЗ) вдаль составила $0,96 \pm 0,16$, на 40 см — $0,77 \pm 0,17$ и на 70 см — $0,64 \pm 0,15$. Снижение остроты зрения до 0,2 отмечалось на двух глазах (4 %). Планируемая клиническая рефракция на доминантном глазу — эметропия наблюдалась у 72 % пациентов, в 28 % случаев зафиксирован сдвиг до $-0,75$ Дптр. Целевая рефракция ($\approx -0,75$ Дптр) на недоминантном глазу отмечалась у 68 % пациентов, сдвиг планируемой рефракции на $-0,50$ Дптр имели 12 и 20 % пациентов на $-0,75$ Дптр. Сферическая аберрация в шестимиллиметровой зоне составила $-0,22 \pm 0,17$ мм. В группе 2 через год после операции бинокулярная НКОЗ вдаль — $1,00 \pm 0,10$, на расстоянии 40 см — $0,37 \pm 0,16$, 70 см — $0,43 \pm 0,12$. Потери монокулярной максимальной корригированной остроты зрения (МКОЗ) вдаль не наблюдалось. Отклонение клинической рефракции от планируемой (эметропии) было определено у 4 % пациентов на $-0,50$ Дптр. Сферическая аберрация в шестимиллиметровой зоне составила $-0,10 \pm 0,08$ мм. **Заключение.** Метод ФРК с нанесением мультифокального биасферического профиля, в отличие от ЛАСИК, позволяет не только добиться коррекции гиперметропии, но и повысить остроту зрения вблизи у пациентов «пресбиопического возраста».

✧ **Ключевые слова:** пресбиопия; гиперметропия; ЛАСИК; ФРК; мультифокальный биасферический профиль; PresbyMax.

BACKGROUND

Laser-assisted *in-situ* keratomileusis (LASIK) currently occupies a leading position among excimer laser surgeries for hyperopia correction. Compared with photorefractive keratectomy (PRK), LASIK is characterized by high efficiency, predictability, rapid recovery of visual functions, and minimal discomfort for patients [10, 11, 14]. However, LASIK surgery has disadvantages, including higher risk of ectasia, requirement for a sufficient corneal thickness, prolonged restriction of physical activity, and impaired biomechanical strength of the cornea after the procedure [12, 13].

Patients planning to undergo laser correction usually endeavor to gain independence from glasses for all distances. However, it should be noted that patients require glasses for near vision even after standard laser correction and those above 40 years of age often have decreased accommodation [4, 6]. Particular caution should be taken in cases requiring simultaneous excimer laser correction of ametropia and presbyopia. Further, LASIK surgery is contraindicated in patients with age-related degenerative changes affecting the eyes, which often compel the rejection of LASIK in favor of PRK with the application of a bi-aspheric mul-

tifocal profile on the cornea using the PresbyMax software, which creates slight anisometropia (micro-monovision) that allows simultaneous correction of ametropia and presbyopia [1–6, 8, 9].

The monovision strategy is based on creating an artificial anisometropia when one eye (leading) is corrected for distance vision, whereas the other is corrected for near vision by forming slight myopia. In this case, the effect of addition is caused by anisometropia and does not exceed 1.5 dioptres (D) [7]. The PresbyMax software allows the generation of a bi-aspheric multifocal profile in the cornea. In the dominant eye, a low myopic refraction is created in the central area (for intermediate vision) and an emmetropic refraction in the peripheral area (for distance vision). In the non-dominant eye, low myopic refraction is generated in the peripheral area, whereas more significant refraction is generated in the central area (Figure 1). This profile provides a good near, intermediate (70 cm), and distant visual acuity.

In addition, a slight negative spherical aberration is created to increase the depth of focus, improve binocular and stereoscopic vision, and minimize the loss of contrast sensitivity.

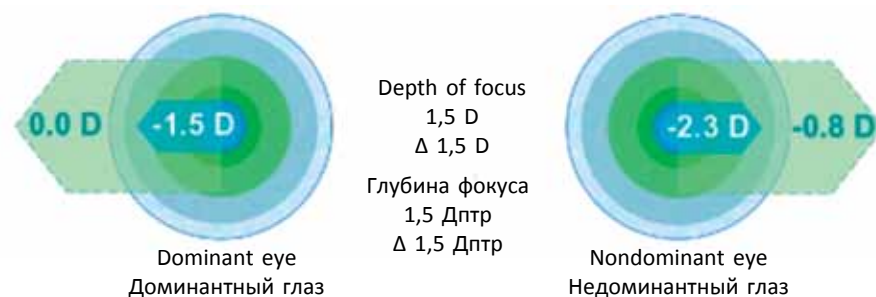


Fig. 1. Multifocal cornea ablation profiles generated with “Presbi-max” software.

Рис. 1. Профили мультифокальной абляции роговицы, формируемые в программном обеспечении «Пресбимакс»

This approach to ametropia correction improves visual comfort and social adaptation in patients of presbyopic age by providing independence from glasses. However, several issues regarding this treatment strategy remain unclear. They include the degree of adaptation and patient satisfaction with an offered multifocal profile and anisometropia, preservation of visual quality, and patient satisfaction with the surgery compared to conventional excimer laser refractive surgery.

The present study was designed to compare the efficacy, safety, and predictability of two surgical methods: simultaneous correction of hyperopia and presbyopia using PRK with the application of a bi-aspheric multifocal profile on the cornea and LASIK correction of hyperopia using the Schwind Amaris laser system (Germany).

MATERIALS AND METHODS

The present study included patients with hyperopia and presbyopia categorized into two groups: the first group comprised patients who underwent PRK with application of a bi-aspheric multifocal profile on the cornea for simultaneous correction of hyperopia and presbyopia; the second group comprised patients who underwent LASIK surgery with the application of a standard aspheric profile to correct hyperopia.

The first group included 25 patients (50 eyes) aged 40–57 years (mean age, 48.9 ± 8.1 years) with hyperopia between +0.50 D and +4.75 D and astigmatism of 0.50–1.00 D. The group consisted of 9 males and 16 females. The mean spherical equivalent refraction was $+1.86 \pm 0.18$ D.

The second group included 25 patients (50 eyes) aged 40–55 years (mean age, 47.5 ± 7.5 years) with hyperopia between +1.00 D and +5.00 D and astigmatism of 0.50–1.00 D. The group consisted of 13 males and 7 females. The mean spherical equivalent refraction was $+1.98 \pm 0.94$ D.

Inclusion criteria:

- 1) Spherical equivalent refraction from +0.50 D to +5.00 D;
- 2) Age between 40 and 60 years;
- 3) No history of keratorefractive surgeries;
- 4) Preoperative keratometry values between 40 D and 43 D;
- 5) Central corneal pachymetry over 500 μ m;
- 6) Best-corrected distance visual acuity (BCDVA) of 1.0 or higher;
- 7) Maximum near visual acuity (NVA) of 0.6 and higher;
- 8) Pupillometry values of 2.5–3.0 mm in photopic conditions (40 lux) and of 4.5–6.8 in scotopic conditions (0.04 lux).

Exclusion criteria:

- 1) All standard contraindications to refractive surgery;

Additional exclusion criteria in the first group:

- 1) Amblyopia in one eye or in both eyes;
- 2) Some professionally related contraindications, including a requirement for maximum uncorrected monocular distance visual acuity (UCDVA) of 1.0;
- 3) Overstated expectations of patients.

Before surgery, all patients underwent standard ophthalmologic examination, including Ref/Keratometer evaluation, monocular visual acuity measurement, binocular UCDVA and BCDVA measurement, pneumotonometry, and biomicroscopy, additional examinations including measurement of monocular/binocular uncorrected/corrected visual acuity (UCVA/CVA) at distances of 70 cm and 40 cm, ADD measurement at distances of 70 cm and 40 cm, identification of the type of vision and dominant eye using the Worth 4 dot test and Check test, optical keratometry, pachymetry, evaluation of the anterior and posterior corneal elevation and the diameter of cornea, assessment of higher-order aberrations (including spherical aberration), and pupillometry under different lighting conditions (photopic at 40 lux, mesopic at 4 lux, and scotopic at 0.04 lux) using the Schwind Sirius diagnostic system (Germany). Patients from the first group were additionally interviewed to assess self-reported visual quality using the National Eye Institute's Visual Function Questionnaire.

Surgeries in both groups were performed by the same surgeon using the Schwind Amaris 500 laser system (Germany).

Main characteristics of surgery performed in the first group

Excimer laser correction using PRK with application of a bi-aspheric multifocal profile with creating slight anisometropia (Micromonovision concept) was performed as follows:

1. Surgical addition of +1.75 D–+2.25 D depending upon the baseline need for visual correction: less surgical addition was performed with lower requirement for visual correction.
2. Optical area between 6.5 mm and 6.8 mm depending upon the pupil diameter in accordance with manufacturer's nomograms. The diameter of the optical area was not less than the pupil diameter in scotopic conditions.
3. Target refraction: emmetropia in the dominant eye and myopia higher than –0.75 D in the non-dominant eye.

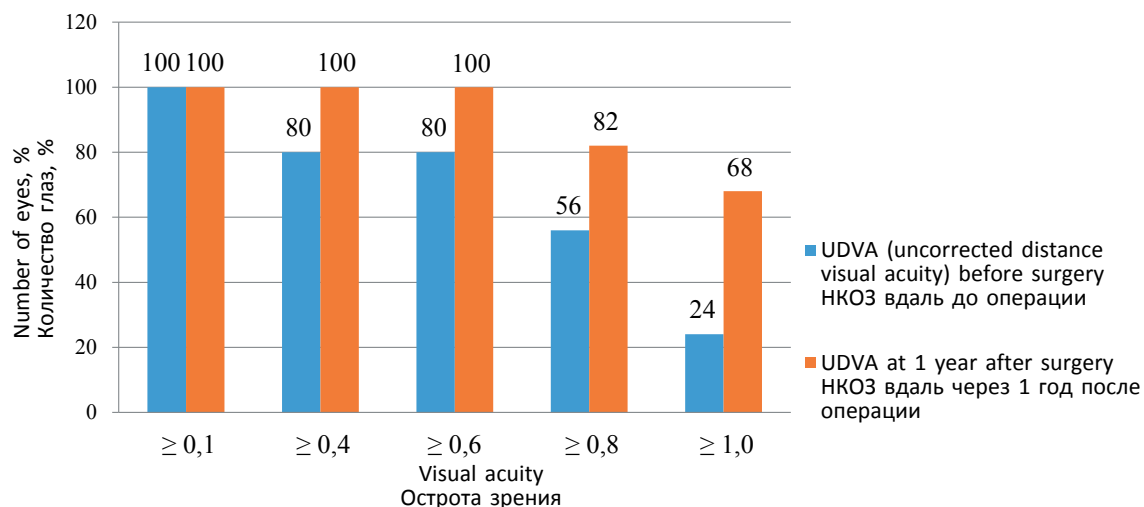


Fig. 2. Binocular uncorrected distance visual acuity before surgery and at 1 year after it in group 1 ($n = 50$)

Рис. 2. Распределение некорригированной бинокулярной остроты зрения вдаль до и через 1 год после операции в группе 1 ($n = 50$)

Main characteristics of the surgery in the second group (LASIK)

- 1) Optical area between 6.5 and 7.0 mm.
- 2) Target refraction: emmetropia in both eyes.

Examination time-points in both groups: prior to surgery, 24 hours postoperatively, the day of epithelialization (only for the first group, 3–4 days postoperatively), and then 1, 3, 6, and 12 months postoperatively.

RESULTS

In the first group, epithelialization occurred 2.5–4 days postoperatively. At this time-point (3–4 days postoperatively), the mean monocular UCVA in the dominant and non-dominant eyes was 0.28 ± 0.20 and 0.23 ± 0.20 , respectively. Postoperatively, the mean UCVA in the dominant eye was 0.55 ± 0.24 at one month, 0.70 ± 0.20 at 3 months,

0.81 ± 0.24 at 6 months, and 0.85 ± 0.23 at one year. In the non-dominant eye (with artificial myopic refraction), the mean UCVA postoperatively was 0.29 ± 0.19 at one month, 0.47 ± 0.25 at 3 months, 0.55 ± 0.28 at 6 months, and 0.60 ± 0.28 at one year.

The mean binocular UCDVA postoperatively was 0.57 ± 0.07 at one month, -0.77 ± 0.14 at 3 months, 0.87 ± 0.23 at 6 months, and 0.96 ± 0.16 at one year. Prior to surgery, the mean UCDVA in this group was 0.65 ± 0.28 (Figure 2). Our data support the efficacy of this type of surgery; however, the period of UCDVA restoration was rather long. Only 3 months postoperatively, the mean binocular UCDVA became higher than that before surgery. The loss of monocular BCDVA (1–2 lines) was observed in 2 (4%) of eyes.

The mean UCVA at a distance of 40 cm in the non-dominant eye was as follows: 0.51 ± 0.23 at

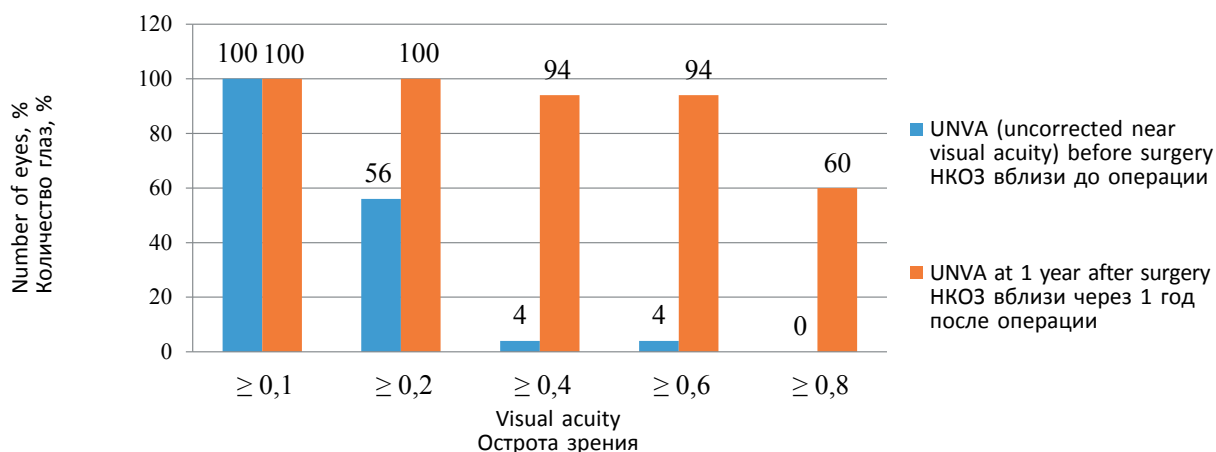


Fig. 3. Binocular uncorrected near visual acuity (40 cm) before surgery and at 1 year after it in group 1 ($n = 50$)

Рис. 3. Распределение некорригированной бинокулярной остроты зрения вблизи (40 см) до операции и через 1 год после операции в группе 1 ($n = 50$)

3–4 days postoperatively, 0.67 ± 0.19 at 1 month postoperatively, 0.74 ± 0.18 at 3 months postoperatively, 0.67 ± 0.20 at 6 months postoperatively, and 0.64 ± 0.17 at 12 months postoperatively. In the dominant eye, the mean uncorrected NVA (UCNVA) was 0.50 ± 0.07 on the day of epithelialization, 0.56 ± 0.21 at one and six months postoperatively, and 0.51 ± 0.23 at one year postoperatively.

Prior to surgery, the mean binocular UCVA at a distance of 40 cm was 0.21 ± 0.12 . On the day of epithelialization, the mean binocular UCVA was 0.55 ± 0.21 , and 0.77 ± 0.19 at one month postoperatively with no further changes observed during the follow-up period (Figure 3). During the year, 96% of patients demonstrated high binocular NVA (over 0.6) and did not require any addition. In 4% of patients, the binocular NVA was lower (0.5) requiring addition of no more than 0.75 D. These data indicate the potential of this method for effective correction of NVA in this patient population.

In the first group, postoperative monocular UCVA at a distance of 70 cm did not significantly differ between dominant and non-dominant eyes at any point during the follow-up period. On the day of epithelialization, the mean monocular UCVA it was 0.20 ± 0.07 and 0.18 ± 0.15 in the dominant and non-dominant eyes, respectively, and then 0.43 ± 0.07 and 0.37 ± 0.14 at one month postoperatively, 0.5 ± 0.14 and 0.44 ± 0.18 at 3 months postoperatively, and 0.56 ± 0.20 and 0.56 ± 0.16 at one year postoperatively ($P > 0.05$).

Binocular UCVA at a distance of 70 cm was 0.21 ± 0.03 prior to surgery. Postoperatively, the mean binocular UCVA was 0.46 ± 0.14 at one month, 0.56 ± 0.10 at 3 months, and 0.64 ± 0.15 at 6 and 12 months.

In the second group, the mean postoperative monocular and binocular UCDVA were 0.87 ± 0.13 and 0.97 ± 0.05 at one month, 0.92 ± 0.09 and 1.00 ± 0.10 at 3 months, 0.98 ± 0.07 and 1.00 ± 0.10 at 6 months, and 0.98 ± 0.07 and 1.00 ± 0.10 at one year, respectively, which was higher than values observed in the first group ($P < 0.05$). Prior to surgery, the mean binocular UCDVA was 0.27 ± 0.19 and the mean monocular UCDVA was 0.18 ± 0.13 . We observed no loss of monocular BCDVA.

In the second group, binocular UCVA at a distance of 40 cm was 0.18 ± 0.08 prior to surgery. One month postoperatively, this value reached 0.51 ± 0.14 , had decreased to 0.42 ± 0.17 at 3 months, and remained at approximately the same level during the rest of the year (0.37 ± 0.16 at one year). Monocular UCVA at a distance of 40 cm was 0.10 ± 0.05 prior

to surgery, 0.46 ± 0.22 – one month postoperatively; by the third month it decreased to 0.29 ± 0.18 , and remained stable during the rest of the year.

Prior to surgery, the mean binocular and monocular UCVA at a distance of 70 cm were 3.00 ± 0.08 and 0.21 ± 0.08 , respectively. Postoperatively, these values were 0.60 ± 0.16 and 0.54 ± 0.19 at one month and 0.46 ± 0.13 and 0.37 ± 0.16 at 3 months, with no further changes observed over the follow-up period.

Comparison of binocular UCVA prior to surgery and at different time-points postoperatively demonstrated a postoperative distance visual acuity (DVA) of 0.97 ± 0.05 in the second group that remained stable during the whole year. In the second group, the postoperative DVA at one month was 0.57 ± 0.07 ($P < 0.05$), before gradually increasing throughout the year (due to the long-term stabilization of the refractive effect).

In the second group, binocular UCVA at a distance of 40 and 70 cm was lower than in the first group ($P < 0.05$). The UCNVA was higher in the first group compared to the second group and comprised 0.77 ± 0.16 and 0.51 ± 0.14 1 month postoperatively, 0.78 ± 0.10 and 0.42 ± 0.17 – 3 month postoperatively, and 0.77 ± 0.17 and 0.37 ± 0.16 – 1 year postoperatively.

One month postoperatively, the mean binocular UCVA at a distance of 70 cm did not differ significantly between the groups. By the end of the third month, this value was higher in the first group compared to the second group (0.56 ± 0.10 vs 0.46 ± 0.13 ; $P > 0.05$). At the 6-month time-point, the mean binocular UCVA were 0.65 ± 0.16 and 0.43 ± 0.12 ($P > 0.05$) in the first and second groups, respectively; and these values did not change over the remaining follow-up period. Comparisons of binocular and monocular UCVA between groups are presented in Figure 1 and Table 1.

The mean clinical refraction in the first group at one year postoperatively was 0.19 ± 0.17 D and -0.79 ± 0.41 D in the dominant and non-dominant eyes, respectively. The ratio of target and resulting refraction is shown in Figures 5 and 6.

A total of 72% of patients achieved target refraction (emmetropia) in the dominant eye. A shift towards myopia was observed in 28% of cases (by -0.5 D in 20% and by -0.75 D in 8%). In the non-dominant eye, target refraction (greater than -0.75 D) was achieved in 68% of cases, whereas 32% of patients failed to reach this value: 12% had a -0.5 D shift and 20% had a -0.75 D shift. These patients had no complaints regarding their DVA.

In the second group, the mean clinical refraction at one year postoperatively was 0.05 ± 0.18 D. Target emmetropic refraction was achieved in 96% of cases, whereas 4% had a slight shift (0.5 D) towards myopia (Figure 7).

Initially positive spherical aberration became negative after laser correction and differed at the 4 mm and 6 mm optical zones in both groups.

In the first group, the mean pre- and postoperative (after 1 year) spherical aberration at the 4 mm opti-

Table 1

Recovery of uncorrected visual acuity at different distances according to study group (* $P < 0,05$)

Таблица 1

Динамика восстановления некорригированной остроты зрения на разных расстояниях в исследуемых группах (* $p < 0,05$)

Time-point	Prior to surgery, <i>n</i> = 50	Day of complete epithelialization, <i>n</i> = 50	1 month post surgery, <i>n</i> = 50	3 months post surgery, <i>n</i> = 50	6 months post surgery, <i>n</i> = 50	1 year post surgery, <i>n</i> = 50
Binocular vision, first group						
Distance	0.65 ± 0.28	0.35 ± 0.08	$0.57 \pm 0.07^*$	$0.77 \pm 0.14^*$	$0.87 \pm 0.23^*$	$0.96 \pm 0.16^*$
70 cm	0.21 ± 0.03	0.27 ± 0.16	0.46 ± 0.14	0.56 ± 0.10	0.65 ± 0.16	0.64 ± 0.15
40 cm	0.21 ± 0.12	0.55 ± 0.21	$0.77 \pm 0.19^*$	$0.78 \pm 0.10^*$	$0.78 \pm 0.12^*$	$0.77 \pm 0.17^*$
Monocular vision (dominant eye), first group						
Distance	0.58 ± 0.29	0.28 ± 0.20	0.55 ± 0.24	0.70 ± 0.20	$0.81 \pm 0.24^*$	$0.85 \pm 0.23^*$
70 cm	0.19 ± 0.08	0.20 ± 0.07	0.43 ± 0.07	0.50 ± 0.14	0.56 ± 0.28	0.56 ± 0.20
40 cm	0.16 ± 0.1	0.50 ± 0.07	$0.56 \pm 0.21^*$	0.60 ± 0.21	$0.56 \pm 0.21^*$	0.51 ± 0.23
Monocular vision (non-dominant eye), first group						
Distance	0.49 ± 0.27	0.23 ± 0.20	0.29 ± 0.19	$0.47 \pm 0.25^*$	$0.55 \pm 0.28^*$	$0.60 \pm 0.28^*$
70 cm	0.15 ± 0.07	0.18 ± 0.15	0.37 ± 0.14	0.44 ± 0.18	0.56 ± 0.21	0.56 ± 0.16
40 cm	0.14 ± 0.07	0.51 ± 0.20	0.67 ± 0.19	0.74 ± 0.18	$0.67 \pm 0.20^*$	$0.64 \pm 0.17^*$
Binocular vision, second group						
Distance	0.27 ± 0.19	—	$0.97 \pm 0.05^*$	$1.00 \pm 0.10^*$	$1.00 \pm 0.10^*$	$1.00 \pm 0.10^*$
70 cm	3.00 ± 0.08	—	0.60 ± 0.16	0.46 ± 0.13	0.43 ± 0.12	0.43 ± 0.12
40 cm	0.18 ± 0.08	—	0.51 ± 0.14	0.42 ± 0.17	$0.38 \pm 0.16^*$	$0.37 \pm 0.16^*$
Monocular vision, second group						
Distance	0.18 ± 0.13	—	0.87 ± 0.13	$0.92 \pm 0.09^*$	$0.98 \pm 0.07^*$	$0.98 \pm 0.07^*$
70 cm	0.21 ± 0.08	—	0.54 ± 0.19	0.37 ± 0.16	0.37 ± 0.16	0.37 ± 0.16
40 cm	0.10 ± 0.05	—	$0.46 \pm 0.22^*$	0.29 ± 0.18	$0.28 \pm 0.15^*$	$0.28 \pm 0.15^*$

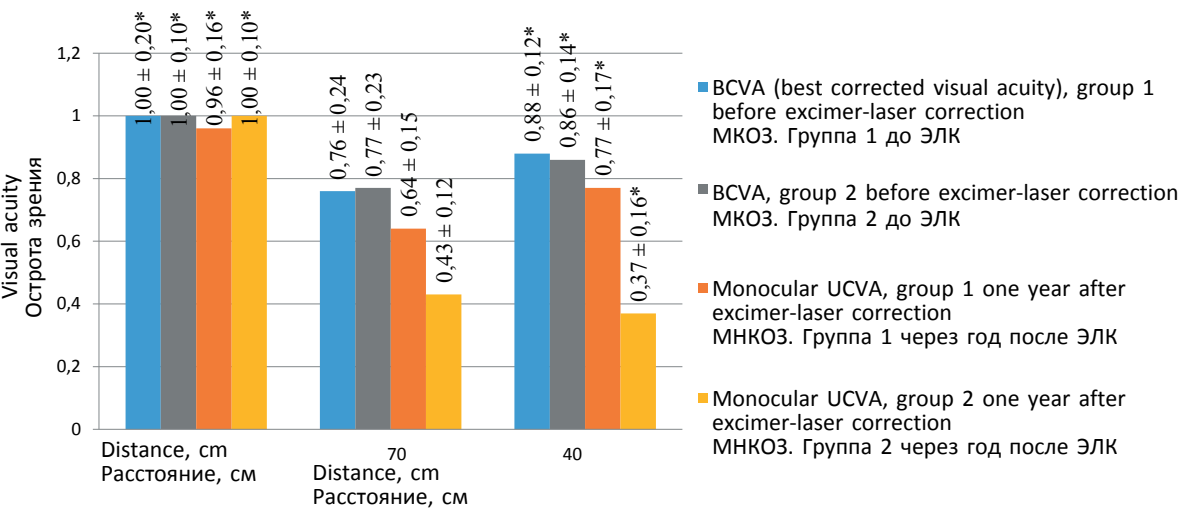


Fig. 4. Comparison of the binocular uncorrected visual acuity at all distances at 1 year after surgery ($P < 0.05$)

Рис. 4. Сравнение бинокулярной некорригированной остроты зрения на всех расстояниях через 1 год после операции ($p < 0,05$)

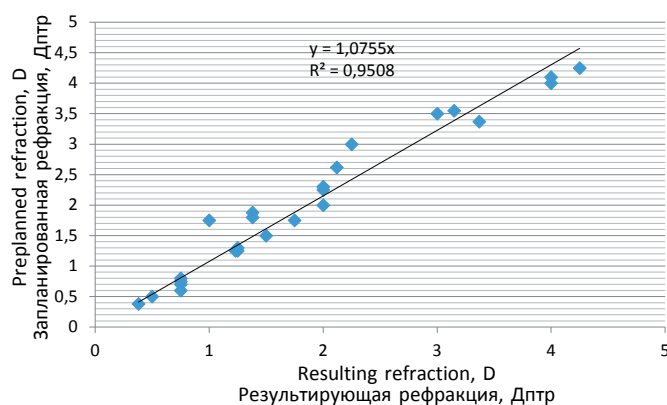


Fig. 5. Distribution of the dominant eye clinical refraction types in group 1 at one year after surgery ($n = 25$)

Рис. 5. График распределения клинической рефракции на доминантном глазу в группе 1 через год после операции ($n = 25$)

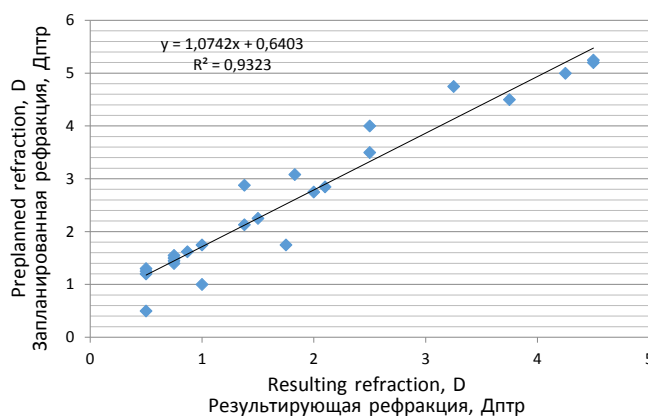


Fig. 6. Distribution of the nondominant eye clinical refraction types in group 1 at one year after surgery ($n = 25$)

Рис. 6. График распределения клинической рефракции на недоминантном глазу в группе 1 через год после операции ($n = 25$)

cal zone was $0.06 \pm 0.01 \mu\text{m}$ and $-0.06 \pm 0.05 \mu\text{m}$, respectively ($P < 0.05$). Spherical aberration at the 6 mm optical zone was $0.22 \pm 0.02 \mu\text{m}$ before surgery and $-0.22 \pm 0.17 \mu\text{m}$ postoperatively ($P < 0.05$). In the dominant eye, spherical aberration at the 4 mm optical zone was $0.06 \pm 0.02 \mu\text{m}$ prior to surgery and $-0.05 \pm 0.02 \mu\text{m}$ at one year postoperatively; at the 6 mm optical zone these values were $0.23 \pm 0.06 \mu\text{m}$ and $-0.17 \pm 0.15 \mu\text{m}$ preoperatively and at one year postoperatively, respectively. In the dominant eye, spherical aberration at the 4 mm optical zone was $0.06 \pm 0.02 \mu\text{m}$ prior to surgery and $-0.1 \pm 0.04 \mu\text{m}$ 1 year postoperatively; at the 6 mm optical zone it was $0.22 \pm 0.08 \mu\text{m}$ and $-0.27 \pm 0.2 \mu\text{m}$ before and 1 year postoperatively respectively.

Patients in the second group also demonstrated a conversion in spherical aberration; however, his value was lower than in the first group. Post-correctional (after 1 year) spherical aberration at the 4 mm optical zone was $-0.03 \pm 0.03 \mu\text{m}$, and $-0.10 \pm 0.08 \mu\text{m}$ at the 6 mm optical zone (Table 2).

The assessment of self-reported quality of vision (using the National Eye Institute's Visual Function Questionnaire) demonstrated that patients in the first group had high quality of vision with complete independence from spectacles, complete satisfaction with the results of surgery (during driving and working at close distances), and improved quality of life. Mean quality of vision scores were 28.78 ± 5 preoperatively, 22.9 ± 4 at 6 months after correction, and 22.4 ± 4.6 at one year after correction.

CONCLUSION

In the present article, we have discussed different approaches to excimer laser correction of hyperopia.

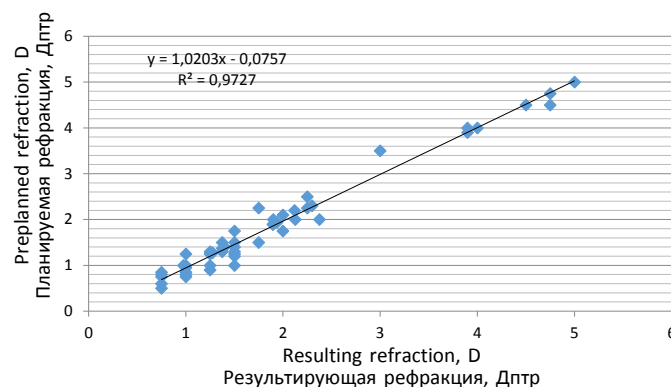


Fig. 7. Clinical refraction type distribution in group 2 at one year after surgery ($n = 50$)

Рис. 7. График распределения клинической рефракции в группе 2 через год после операции ($n = 50$)

The LASIK procedure is performed by cutting a corneal flap with further ablation of the stroma inferiorly and correction of hyperopia only, whereas the PRK technique creates a complex bi-aspheric multifocal profile that enables both hyperopia and presbyopia correction. This effect explains the differences observed in the present study.

The maximum monocular and binocular UCVA were higher in patients after LASIK, which does not cause losses in maximal distant visual acuity. The method is highly predictable; however, patients with presbyopia do not gain sufficient near and intermediate visual acuity after LASIK correction and have to use glasses for reading. There was a significant change in spherical aberration (from positive to negative) in both groups according to the ablation profile for the correction of hyperopia. However, these changes were insufficient in the second group. Increasing spherical aberration of the cornea only was unable to provide complete independence from glass-

Table 2

Spherical aberration at the 4 mm and 6 mm optical zones (* $P < 0,05$)

Таблица 2

Сферическая аберрация в четырёхмиллиметровой и шестимиллиметровой зонах (* $p < 0,05$)

Time-point	Spherical aberration, μm (at 6 mm)	Spherical aberration, μm (at 4 mm)
First group ($n = 50$)		
Prior to surgery	$0.22 \pm 0.02^*$	$0.06 \pm 0.01^*$
6 months post surgery	$-0.23 \pm 0.20^*$	$-0.07 \pm 0.05^*$
1 year post surgery	$-0.22 \pm 0.17^*$	$-0.06 \pm 0.05^*$
Second group ($n = 50$)		
Prior to surgery	$0.19 \pm 0.02^*$	$0.03 \pm 0.01^*$
6 months post surgery	-0.15 ± 0.07	-0.03 ± 0.03
1 year post surgery	$-0.10 \pm 0.08^*$	$-0.03 \pm 0.03^*$

es and high NVA. Therefore, the multifocal corneal profile combined with a negative spherical aberration increasing from the center to the periphery provides maximum increase in depth of focus with a continuous distribution of optical power in the area between the center and periphery.

The use of PRK with application of a bi-aspheric multifocal profile on the cornea enables simultaneous correction of hyperopia and presbyopia and achievement of high visual acuity at all distances. Despite established opinion regarding the smoothing function of the corneal epithelium during the application of complex profiles on the cornea, we managed to achieve both refractive and aberration effects. The recovery of DVA in patients after PRK was naturally longer than in patients after LASIK. This difference is associated with reparative processes in the cornea after creation of a bi-aspheric multifocal profile. By the end of first month after surgery, binocular UCVA comprised 50% of the maximum target visual acuity and increased with each time-point. After a year, the differences between groups became non-significant.

Satisfactory binocular NVA and visual acuity at 40 cm was achieved on the day of epithelialization (3–4 days postoperatively) and continued to increase reaching a maximum after 1 month. The value of UCNVA was significantly higher in patients after PRK than in patients after LASIK.

The quality of vision among patients treated with LASIK remained high throughout the year of follow-up, as indicated by the high scores from visual quality questionnaires.

Over 72% of patients with a multifocal profile combined with PRK achieved target refraction, which indicates the high predictability of the method despite being inferior to LASIK in terms of predictability. Accordingly, simultaneous correction of hyperopia and

presbyopia by PRK with application of a bi-aspheric multifocal profile on the cornea using the PresbyMax software creating slight anisometropia (Micromonovision concept) is preferable to traditional laser correction (LASIK) as it ensures high visual acuity at different distances and is effective in patients with a combination of hyperopia and presbyopia.

In our opinion, it is possible to perform further optimization of this method and the profile of ametropia and presbyopia correction in order to speed up postoperative visual adaptation and recovery of DVA. Development of specific profiles for LASIK surgery may also have utility in clinical practice.

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